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TECHNICAL PHYSICS

Transparency of the Surface Atmosphere to the Radiation of a Pulsed CO_2 Laser

947J0001A Tomsk OPTIKA ATMOSFERY I OKEANA in Russian Vol 6 No 4, Apr 93 (manuscript received 30 Dec 92) pp 339-344

[Article by V. A. Pogodayev, Institute of Atmospheric Optics, Siberian Division, Russian Academy of Sciences, Tomsk; UDC 5 30.182.551.510.42]

[Abstract] This article attempts to isolate some indicative characteristics of the interaction of intense laser radiation with the surface atmosphere in order to evaluate the effect of gas and aerosol components of attenuation on the transfer coefficient of laser radiation. Experimental data on the attenuation of intense laser radiation in various optical and meteorological conditions (in particular, haze) are analyzed. The ratio between the gas and aerosol components of the atmosphere's attenuation coefficient is found to be significant. Beam propagation geometry is found to play a substantial role (zones of optical breakdown appeared which affected the transparency of the atmospheric channel). When one is developing models of the transfer of laser radiation in the atmosphere one cannot be confined to an additive examination of laser interaction with atmospheric gas and aerosol components. The interactions occur simultaneously, enhancing and competing with each other. In weakly focused beams, only when the contributions of the gas and aerosol components are equal can the transfer of laser radiation in the atmosphere be reliably predicted. Otherwise, great ambiguity is introduced in estimates of laser attenuation. In sharply focused beams attenuation is significantly higher and is unambiguously dependent on the ratio of gas and aerosol contributions to attenuation. The aerosol component makes the key contribution. Figures 2; tables 2; references 11 (Russian).

Spectrophotometric Unit To Measure Absorption of IR, Visible, and UV Laser Radiation by Molecular Gases

947J0001B Tomsk OPTIKA ATMOSFERY I OKEANA in Russian Vol 6 No 4, Apr 93 (manuscript received 18 Dec 92) pp 360-368

[Article by Yu. N. Ponomarev, I. S. Tyryshkin, Institut of Atmospheric Optics, Siberian Division, Russian Academy of Sciences, Tomsk; UDC 539.375]

[Abstract] This article describes a spectrophotometric unit based on a 110 m multiple-pass cell designed to study energy losses of IR, visible, and UV laser radiation in molecular gases and in air. Methods of measuring the absorption coefficient are discussed. Results of measurement of absorption of the radiation of YAG:Nd^{3+} lasers and Nd^{3+}-glass lasers at the fundamental, second, and fourth harmonics by atmospheric air are presented. The construction of the cell is described in detail and a schematic of the laser spectrophotometer is offered. The laser systems for both types of lasers used in this experiment are described. The spectral resolution is 10^{-3} -10^{-2} cm^{-1}. The cell is 112 m long and 0.7 m in diameter with a volume of 45 m^3. The range of pressures it can accommodate is $5X10^{-3}$-10^3. The range of temperatures it can handle is 288-360 K. The error in determining the center of lines is 10^{-3}-10^{-4} nm. Figures 5; table 1; references 11 (Russia n).

Laser Beam Propagation Along Vertical and Slanted Extended Paths Through a Turbulent Atmosphere

947J0001C Tomsk OPTIKA ATMOSFERY I OKEANA in Russian Vol 6 No 4, Apr 93 (manuscript received 30 Dec 92) pp 377-385

[Article by V. A. Banakh, I. N. Smalikho, Institute of Atmospheric Optics, Siberian Division, Russian Academy of Sciences, Tomsk; UDC 538.574.8]

[Abstract] The mean value, relative dispersion, and scales of spatial and temporal correlation of the intensity of focused and collimated laser beams in the far diffraction range are analyzed in propagation through a turbulent atmosphere along slanted and vertical paths whose lengths substantially exceed the thickness of the distorting layer. It is found that on these paths the temporal scale of correlation of fluctuations in intensity is completely characterized by the transfer time of inhomogeneities through the initial cross section of the beam, independent of the level of turbulent distortions in the layer. The spatial scale of correlation coincides with the diffraction size of the beam in the observation plane (if the fluctuations in the amplitude of optical radiation within the layer are small compared to the phase fluctuations) and is proportional to the field coherence radius as it leaves the distorting layer (if the path satisfies conditions which lead to an inverse ratio of amplitude to phase fluctuations). It is shown that the maximum value of the average intensity found in a coordinate system with its origin at the beam's centroid may substantially exceed the average intensity due to random wandering of the beam as a whole. Figures 3; references 17: 14 Russian, 3 Western.

Change in the Index of Refraction in the Active Zone of Powerful Laser Radiation

947J0001D Tomsk OPTIKA ATMOSFERY I OKEANA in Russian Vol 6 No 4, Apr 93 (manuscript received 30 Dec 92) pp 386-391

[Article by V. V. Karasev, Yu. A. Konyayev, V. M. Sazonovich, R. Sh. Tsvyk, Institute of Atmospheric Optics, Siberian Division, Russian Academy of Sciences, Tomsk; UDC 621.378.325]

[Abstract] This article describes a method of determining the total change in the index of refraction in the active zone of strong optical radiation from the shift in the image of the source of the sounding beam that intersects the active zone at an angle to the axis.

Experimental results are obtained f or the change in the index of refraction along a branchless path, and these results are compared with theoretical ones. It is shown that for winds higher than 2 m/s the nonlinear thermal lens (calm zone) formed in the initial part of the path has a significant effect on distortion of a beam of strong laser radiation at the end of the path. Figures 3; references 8 (Russian).

Hot Target Plasma for Controlled Thermonuclear Fusion

947J0005A Moscow DOKLADY AKADEMII NAUK in Russian Vol 332 No 2, Sep 93 (manuscript received 28 Apr 93) pp 155-157

[Article by G.I. Dimov, corresponding member of Russian Academy of Sciences, Ye.A. Gilev, A.A. Kabantsev, V.G. Sokolov, and S.Yu. Taskayev, Institute of Nuclear Physics at Russian Academy of Sciences, Siberian Department, Novosibirsk; UDC 533.916.03:621.039.61]

[Abstract] Generating a stationary hot plasma with the ion temperature within the 10-100 keV range is considered for a study of controlled thermonuclear fusion, such a plasma being trapped in an open magnetic bottle and forming a target here either for subsequent extraction of high-energy ions from high-intensity atomic beams by the charge transfer and ionization mechanism or for subsequent emission of high-frequency radiation. The usual plasma source is an array of gas-discharge arcs. A plasma jet is formed here which an attenuating magnetic mirror then reflects into the magnetic bottle which thus becomes filled with a low-temperature (about 10 eV) low-density (about 10^{14} cm^{-3}) plasma target. The lifetime of subsequently captured hot ions in terms of energy retention depends on the plasma electron temperature, as does the degree of plasma polarization, and is in this case about 10 μs long: hot ions losing their energy during collisions with electrons rather than by dissipation into the loss cone or by charge transfer to the atomic beams and to the residual gas. In order to raise the electron temperature appreciably and in this way lengthen the lifetime of hot ions, their lifetime being proportional to the three-halves power of the electron temperature and inversely proportional to the electron concentration, it is necessary to minimize the heat losses along the entire path of electrons from the plasma source (gas-discharge arcs) to the plasma trap (magnetic bottle) by means of a thermal barrier (magnetic potential hill). This was accomplished experimentally by formation of a plasma jet flowing adiabatically in a magnetic field steeply rising along the jet with $|B/(dB/dz)| < L_t$ (L_t- length of ion temperature relaxation path along flow degrees of freedom) and by use of a magnetic mirror forming an anisotropic plasma density distribution with a local minimum (top of a potential barrier) somewhere between the plasma source and the plasma trap. Transport of the plasma in the magnetic field gave rise to a Keldysh-Helmholtz instability. While tapering of the plasma density due to action of the magnetic mirror lengthened the time of temperature equalization between transversely and forward moving ions, further tapering of the plasma density took place owing to the strong temperature anisotropy of ions ($T_{trans} >> T_{long}$) sustained by continuous energy transfer to the transversely moving ones within the instability region. Experiments were performed with the AMBAL-Yu plasma trap, a quadrupole obturator having a 2:1 lock ratio and an absolute minimum in its magnetic field distribution. This trap was filled with arc- discharge hydrogen plasma to a concentration of about $3x10^{13}$ cm^{-3} with an above 50 eV electron temperature, an about 1 keV ion temperature, and an about 0.06 beta factor. Tests with injection of about 17 keV atomic hydrogen beams in pulses of 200 μs duration revealed a satisfactory performance of such a plasma target: electron temperature 80 eV, ion stagnation time 300 μs following collisions with electrons, ion dissipation into loss cone time 410 μs, and concentration of hot ions $3x10^{12}$ cm^{-3} at the end of an atomic beam injection pulse. When deuterium is used as the plasma-generating gas, then nuclear fusion reactions take place in the plasma. At an about 1 keV temperature of the deuton target plasma, a total neutron flux of the order of 10^8 neutrons per second should emanate from the obturator, which has been confirmed by measurements made with a neutron detector located outside the vacuum chamber and recording "de-excitation" of protons in polystyrene. Figures 3; references 5.

Electrically Stimulated Change in Chemical Composition of $(Bi,Pb)_2 Sr_2Ca_2Cu_3O_8$ High- T_c Superconductor Films at 4.2 K Temperature

947J0006A Moscow DOKLADY AKADEMII NAUK in Russian VOl 332 No 3, Sep 93 (manuscript received 1 Jun 93) pp 303-305

[Article by Ye.N. Lubnin, G.N. Mikhaylova, T.Ye. Oskina, Academician A.M. Prokhorov, A.S. Seferov, and A.V. Trotskiy, Institute of General Physics at Russian Academy of Sciences, Moscow; UDC 537.312.62]

[Abstract] Use of 2223-phase Bi-Sr-Ca-Cu-O films for superconducting cables is considered, inasmuch as material containing bismuth features not only excellent critical parameters but also a higher chemical stability than that of 123-phase Y-Ba-Cu-O material. Following earlier experiments with ceramic Y-Ba-Cu-O films, an experimental study on Bi-ceramic films was made concerning the possibility of diffusing heavy ions in such films so as to partially alter the composition of the material by passage of an electric current through it. The experiment was performed on about 25 μm thick ceramic Bi(Pb)-Sr-Ca-Cu-O films with an about 5x10 mm^2 surface area which had been grown by deposition of superconducting $Bi_{1.7}$ $Pb_{0.4}Sr_{1.9}Ca_{2.03}Cu_{3.06}$ O_x powder on a silver substrate and subsequently to cyclic pressing-rolling-annealing treatment. The critical superconducting transition temperature of the film material was 102 K based on electrical resistance measurements with a current of 2 mA and 1 Ω indium electrodes (transition began at 109 K) or 105 K based on magnetic susceptibility measurements. Measurements in a magnetic field of 20 Oe intensity yielded a critical current density within 800-1000 A/cm^2 at a 77 K temperature and of 3300 A/cm^2 at a 12 K temperature. With a test specimen and a control specimen held in a flask with helium as coolant under atmospheric pressure at a 4.2 K temperature, a current of 20 mA was passed through the test specimen for 438 h and thus a total charge of 31,536 C transported through it. Phase analysis of the films before and after passage of electric current was done in a DRON-3 x-ray diffractometer with a CuK_α-radiation source, phases then being identified by comparing with reference standard diffractograms of superconducting phases in at least 0.3-0.4 μm thick films of the Bi(Pb)-Sr-Ca-Cu-O system. Morphological examination of the film surface was done under Camscam scanning electron microscope, various image formation techniques yielding information either about the chemical composition of mixed film segments or about the film topography. Chemical nonhomogeneity and the volume fractions of phases were determined on the basis of x-ray spectrum microanalysis in a Camebax-Micro apparatus and statistical analysis of the data. The original films had smooth surfaces, some segments covered with terraces and fine cracks or whiskers. The principal phase in them was tetragonal $(Bi,Pb)_2$ $Sr_2Ca_2Cu_3O_8$ (85+/-5%), accompanied by the CuO bulk phase (3+/-1%). The remainder were SrO and Bi_2O_3 oxides (2+/-0.5% each) or their unidentified complex oxides (about 7%). The stoichiometry of these films corresponded to the $Bi_{1.7}Pb_{0.2}Sr_{1.7}$ $Ca_{1.8}Cu_{2.5}O_{8.5}$ formula. Examination of the films after passage of electric current through them revealed a change of morphology, precipitation of new nonsuperconducting phase with a different crystal symmetries, and a different composition stoichiometry in practically all film segments. In addition to revealing the effect of prolonged current passage on both composition and structure of Bi(Pb)-Sr-Ca-Cu-O films and ceramic, the results of this study also help estimating the life of Bi(Pb)-Sr-Ca-Cu-O films with given levels of "contamination" by extraneous phases. Figures 4; tables 2; references 12.

Phenomenological Theory of Structural and Magnetic Phase Transitions in La_2BO_4 (B = Cu, Ni, Co) Compounds (Review)

937J0116A Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 13 Aug 91) pp 669-697

[Article by N. M. Plakida, Joint Nuclear Research Institute, Dubna, and V. S. Shakhmatov, Physical Energy Institute, Obninsk]

[Abstract] A unified phenomenological Landau theory of structural and magnetic transitions (ST and MT) in La_2BO_4 crystals (B = Cu, Ni, Co) has been developed. An expansion was found for the free energy which describes the entire ensemble of experimentally observed structural and magnetic transitions in this class of compounds. A study was made of the ST series 14/mmm → Cmca → $P4_2/ncm$. Estimates of the phenomenological constants were made. The values of the crystal lattice parameters were used in computing the relative jumps of the hardness coefficients La_{2-x} Sr_xCuO_4 with a ST 14/mmm → Cmca. The microscopic nature of the order parameters (OP) of the ST is discussed. The spin reorientation phase transition (SRPT) was predicted. In the magnetic field directed perpendicularly to the BO_2 base planes the compounds La_{2NiO_4} and La_2CoO_4 in the crystal phase Cmca may experience SRPT in a state with "weak" ferromagnetism. It is shown that the magnetic structures in the crystal phase $P4_2/ncm$ differ from the experimentally determined magnetic structures in the phase Cmca in that the closest spins in the base plane are turned by an angle 45°. Proceeding on the basis of symmetry of the magnetic OP, the jmagnetic structure of La_2CoO_4 and La_2NiO_4 is predicted, as well as that of compounds of the type $La_{2-y}X_yCuO_4$ (where X is a trivalent ion) in the phase $P4_2/ncm$. The SRPT is predicted for compounds of the type $La_{2-y}X_yCuO_4$ in the phase $P4_2/ncm$. It is shown that the interaction of the order parameter of the MT with components of the spontaneous deformation tensor also leads to jumplike

changes of the crystal hardness coefficients. Figures 5; references 6: 5 Russian, 1 Western.

Dependence of Superconducting Transition Temperature in High Temperature Superconductor $YBa_2Cu_3O_{7-\delta}$ on Electron Structure Parameters of CuO_2 Layers

937J0116B Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 5 Nov 92) pp 698-704

[Article by V. F. Yelesin, L. A. Openov and A. I. Podlivayev, Moscow Physical Engineering Institute]

[Abstract] Earlier studies of thin $YBa_2Cu_3O_{7-\delta}$ films by the photoemission spectroscopy method revealed the presence of a correlation between T_c and energy ε of charge exchange from the d-orbitals of copper atoms to the p-orbitals of oxygen atoms. It was found that the greater the ε value, the greater the T_c value. The results of computations of electron polarizability of CuO_2 layers also indicate a sensitivity of the superconducting properties of HTSC to the ε value. The dependence of the binding energy of hole charge carriers on ε was numerically investigated for the case of a purely nonphonon superconductivity mechanism. By a comparison of theoretical computations with experimental data a limitation was found on the possible range of ε values at which the interaction of two holes corresponds to their effective attraction. The Emery method of precise diagonalization of the Hamiltonian was used in computing the dependence of the binding energy of excess holes in a Cu_4O_8 cluster on the energy ε of charge transfer between oxygen and copper atoms in CuO_2 planes. The results are used in explaining the experimentally observed correlation between the temperature of the superconducting transition, oxygen content and ε value in the HTSC $YBa_2Cu_3O_{7-\delta}$. The results were obtained in the numerical simulation of the CuO_2 plane, a common structural element of all copper-oxide HTSC, and therefore can be applied to compositions other than $YBa_2Cu_3O_{7-\delta}$. This would make it interesting to carry out experimental study of charge transfer energy in samples with different T_c in bismuth, thallium and other HTSC systems. Figure 1; references: 7 Western.

Distribution of Normal and Plane Components of Magnetic Induction in Thin HTSC Films

937J0116C Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 29 Oct 92) pp 705-713

[Article by V. K. Vlasko-Vlasov, L. A. Dorosinskiy, M. V. Indenbom, V. I. Nikitenko, A. A. Polyanskiy and R. L. Prozorov, Solid State Physics Institute, Russian Academy of Sciences]

[Abstract] A magnetooptic method is proposed for determining the plane component of the magnetic field on the surface of a superconductor and it is used in a thin YBCO film magnetized perpendicularly to its plane in making the first measurements of the distribution of the tangential component of induction. Simultaneously the profiles of the normal induction component were measured in this film. On the basis of numerical fitting of the profiles of both components the spatial distribution of the screening currents was obtained, demonstrating a difference from the Bean model for a critical state in samples with a high demagnetizing factor. It was demonstrated on the basis of measurements of the perpendicular and tangential components in a normally magnetized superconducting film that the critical state in the main part of the sample is characterized by a constant current density oin accordance with the Bean model, but at the center and at the edges of the film there are broad transition regions where the current density decreases considerably. It is noted that there are significant differences between this study and one made by H. Theuss, et al. in Physica C, Vol 190, p. 345, 1992. Figures 4; references 14: 2 Russian, 12 Western.

Distribution of Superconducting Currents During Remagnetization of Thin YBCuO Film in Normal Field

937J0116D Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 29 Oct 92) pp 714-722

[Article by R. L. Prozorov, A. A. Polyanskiy and V. I. Nikitenko, Solid State Physics Institute, Russian Academy of Sciences; I. V. Grekhov, L. A. Delimova and I. A. Liniychuk, Physical Technical Institute imeni Ioffe]

[Abstract] The magnetooptical method was used in studying induction profiles in a thin YBCO film and the corresponding current distributions were constructed and compared with computations for samples with a high demagnetizing factor. The profiles of the normal magnetic induction component were measured in a thin film of the HTSC in different stages of its remagnetization in a field perpendicular to the surface. By means of computerized processing of the experimental dependencies it was possible to obtain the distributions of superconducting currents in a thin superconducting strip. It was established that during remagnetization there is a change not only of the direction, but also the intensity of the screening current. This is determined by the change in the gradient of the plane component of induction in the thickness of the film and gives evidence that in the remagnetization process the sample is not in a critical state. The determined current distributions were used in computing the macroscopic curve of magnetization of a thin film in a normal field and its difference from the curve for a sample with a zero demagnetizing factor is demonstrated. Figures 6; references 10: 5 Russian, 5 Western.

Study of Surface Currents in HTSC Monocrystals and Thin Films

937J0116E Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 29 Oct 92) pp 723-727

[Article by V. K. Vlasko-Vlasov, L. A. Dorosinskiy, V. I. Nikitenko, A. A. Polyanskiy and R. L. Prozorov, Solid State Physics Institute, Russian Academy of Sciences]

[Abstract] The magnetic induction jump on the surface of monocrystalline samples of a HTSC caused by the Meissner repulsion of the magnetic field and associated with the flowing of a surface current was investigated. The measurements made in different monocrystals and thin films revealed that the intensity and spatial distribution of the surface current are considerably dependent on the defect structure of the sample and also on the demagnetizing fields determined by its form. With the magnetization of a sample cooled in a zero field the surface current intensity is determined not only by the Meissner repulsion of the magnetic field, but also by the influence of the Bean-Livingston surface barrier. The measurements made in monocrystals indicated that at low temperatures the surface barrier in actuality exerts a substantial influence on the magnetization process. A thorough study was made of the flowing of the surface current in these samples for the case of magnetization in the external field. It is shown that its intensity is determined not only by equilibrium factors (that is, the thermodynamically equilibrium value of the field repulsed from the sample), but also is dependent on the structure and geometric dimensions of the sample. The surface current intensity approaches the equilibrium level only in high-quality HTSC monocrystals, but in the presence of weak bonds in the sample it decreases substantially. The surface current also is suppressed in thin samples (most strongly in thin HTSC films) due to magnetic field concentration near their edges. Figures 2; references 9: 2 Russian, 7 Western.

Microwave Absorption in HTSC Monocrystals in Weak Magnetic Fields. Anisotropy and Symmetry of Series of Lines in Microwave Spectra

937J0116F Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 29 Oct 92) pp 728-742

[Article by V. V. Troitskiy, M. A. Krykin, Yu. A. Yazlovetskaya, I. O. Maslennikov, A. A. Bush and V. I. Muromtsev, Physical Chemistry Scientific Research Institute imeni L. Ya. Karpov]

[Abstract] A method was developed for analysis of the spectra of microwave absorption, being a superposition of a series of lines equidistant in the permanent magnetic field B. It was established that each of the series of absorption lines is characterized by its own axis, defined in a coordinate system referenced to the sample, the projections of the permanent and microwave magnetic fields on which all the characteristics of a series of lines (period, position, width, intensity, threshold value of microwave intensity of each line) are determined. A new type of series of microwave absorption lines containing a line with $B = 0$ was discovered. It was found that series of the new type in a HTSC monocrystal accompanies a series of a known type having the same period and axial direction. The lines of the two mentioned types of series are therefore observed with magnetic field values B_n satisfying the relation $B_n = +/-(n + \alpha)\Delta B^0/\cos\gamma$, where $\alpha = 0$ or $1/2$, γ is the angle between the magnetic field B and the axis of the series, ΔB_0 is its minimum period. It is thereby shown that the presence of the new type of series, together with the known type of series, is a result of the existence of two possible sets of transitions ($\alpha = 0; 1/2$) in one absorbing system. Figures 8; references 10: 5 Russian, 5 Western.

Volt-Ampere Characteristics of Ceramic Superconductor $Bi_2Sr_2Ca_2Cu_3O_{8+\delta}$

937J0116G Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 20 Nov 92) pp 743-749

[Article by A. A. Zhukov, D. A. Komarkov, I. Mirkovich, V. P. Shabatin and V. V. Palachev, Moscow State University imeni M. V. Lomonosov]

[Abstract] Many studies have been made of the volt-ampere characteristics (VAC) of ceramic HTSC but the picture remains unclear. Several expressions have been derived for describing the experimental data, but since the data used were obtained in relatively narrow voltage ranges, amounting to several orders of magnitude, the universality of these expressions and the differences between them have remained questionable. A method was developed for contactless measurements of the VAC and relaxation of a screening current having a very low electric field threshold—10^{-13} V/cm and a high speed—1 ms. The combined use of the proposed and traditional four-contact methods made it possible to investigate the VAC of a ceramic superconductor $Bi_2Sr_2Ca_2Cu_3O_{8+\delta}$ in a very broad voltage range (E about 10^{-13}-10^{-1} V/cm). An agreement was obtained between contact and contactless methods. It was established that the experimental data are characterized by an S-like behavior which can be reproduced using the VAC of an individual Josephson contact in the presence of thermal fluctuations. A scaling behavior of the field dependencies of conductivity was discovered for different E levels. Figures 4; references 19: 5 Russian, 14 Western.

Nuclear Quadrupole Resonance Frequencies of Crystallographically Nonequivalent Positions of Copper Atoms $Tl_2Ba_2Ca_2Cu_3O_{10}$

937J0116H Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 8 Oct 92) pp 750-757

[Article by Yu. I. Zhdanov, A. M. Bogdanovich, K. N. Mikhalev, B. A. Aleksashin, V. V. Lavrentyev and S. V.

Verkhovskiy, Physics of Metals Institute, Ural Department, Russian Academy of Sciences; A. I. Akimov and A. P. Chernyakova, Solid State Physics and Semiconductors Institute, Belarus Academy of Sciences]

[Abstract] A joint analysis of the NMR and NQR spectra of ^{63}Cu and $Tl_2Ba_2Ca_{2Cu_3}O_{10}$ made it possible to determine the frequency values of nuclear quadrupole resonance for crystallographically nonequivalent positions of the atoms Cu ν(Cu1) = 16.8 MHz for copper situated between layers of barium and calcium atoms and ν(Cu2) = 10.5 MHz between layers of calcium atoms. The experiments were made in a ceramic unoriented single phase sample of $Tl_2Ba_2Ca_2Cu_3O_{10}$ with a superconducting transition T_c = 123 K. A sample of the composition $Tl_2Ba_2CaCu_2O_8$ with T_c = 105 K was selected as a comparison. Spectral measurements were made using a Bruker SXP4-100 NMR pulsed spectrometer. An analysis of the NQR and NMR spectra of ^{63}Cu confirms that the NQR lines at a frequency ν = 10.5 MHz belong to copper atoms located in an environment of calcium atoms. Figures 6; references 10: 1 Russian, 9 Western.

Spin Susceptibility of CuO_2 Planes in Superconducting Oxides $TlPbBa_2Ca_3Cu_4O_{11}$ and $Tl_2Ba_2Ca_nCu_{n+1}O_{6+2n}$ (n = 0, 1, 2) According to ^{63}Cu NMR Data

937J0116I Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 8 Oct 92) pp 758-766

[Article by A. M. Bogdanovich, K. N. Mikhalev, Yu. I. Zhdanov, Yu. V. Piskunov, S. V. Verkhovskiy, V. V. Lavrentyev and B. A. Aleksashin, Physics of Metals Institute, Ural Department, Russian Academy of Sciences; A. I. Akimov and A. P. Chernyakova, Solid State Physics and Semiconductors Institute, Belarus Academy of Sciences]

[Abstract] The results of measurements of components of the tensor of shifts of the NMR line ^{63}Cu are given for normal and superconducting states for superconducting cuprate based on thallium $(TlPb)Ba_2Ca_3Cu_4O_{11-\delta}$ and $Tl_2Ba_2Ca_nCu_{n+1}O_{6+2n+\delta}$ (n = 0, 1, 2) containing a different number of perovskite planes. The behavior of spin susceptibility in CuO_2 planes containing crystallographically nonequivalent positions of copper atoms is discussed. It is shown that with an increase in the number of perovskite layers, accompanied by a T_c increase, the spin susceptibility remains virtually unchanged; spin susceptibility in CuO_2 planes more distant from acceptor TlO layers is less by a factor of 1.5 (2) than in CuO_2 planes adjacent to a BaO layer. Figures 5; references 19: 5 Russian, 14 Western.

Methods for Studying Relaxation and Elastic Properties of HTSC Within Broad Temperature Range

937J0116J Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 23 Dec 1992) pp 767-770

[Article by B. I. Shapoval, V. A. Finkel and V. D. Krasnikov, Kharkov Physical Technical Institute]

[Abstract] Applicable to ceramic HTSC the method for measuring the attenuation of an ultrasonic wave is less effective than for metals. Accordingly, it was deemed important to develop a method for using infrasonic frequencies in the range from 4.2 K to premelting temperatures. Measurements in the low-temperature region were made using a standard helium cryostat and due to its limited thermostated volume emphasis was on miniaturization of the measuring components while fully retaining the principal characteristics of the high-temperature method: sensitivity and accuracy. A miniaturized measuring system operating in the temperature range from helium or nitrogen to premelting temperatures at low frequencies was therefore developed for the purpose of obtaining the spectrum of mechanical relaxation and the dependence of elastic models of HTSC ceramics on temperature by a dynamic method. The apparatus is represented diagrammatically with 12 components identified; another diagram shows the positioning of measuring instruments in the cryostat with 14 components identified. The measurements are illustrated in the example of the relaxation spectrum of the HTSC $YBa_2Cu_3O_{7-\delta}$ in the temperature range 80-1100 K. In this case for the first time a uniform spectrum of the mechanical relaxation of the material in virtually the entire temperature range of its existence in the form of a solid was registered. Figures 3; references 6: 3 Russian, 3 Western.

Some Technological Aspects of $Y_1Ba_2Cu_3O_{7-\delta}$ Thin Film Production on Large-Diameter Substrates

937J0116K Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 12 Oct 92) pp 771-776

[Article by O. N. Alifertsev, R. F. Akhtyamov, T. Sh. Babayev, L. S. Bykovskaya, Yu. G. Dorogova, D. V. Dyadyushkin and Yu. A. Pukhlyakov, Electronic Technology Materials Scientific Research Institute]

[Abstract] The methods of x-ray diffractometry, Auger spectroscopy and electron microscopy were used in investigating the influence of the growth conditions for thin HTSC films of the composition $Y_1Ba_2Cu_3O_{7-\delta}$ on the critical parameters of superconductivity, structural characteristics, distribution of the principal components by area and surface morphology. The films were precipitated in situ on microwave-traditional substrates (YSZ, MgO, $MdGaO_3$) by the spraying of a stoichiometric ceramic target with a planar magnetron. It is shown that a possible technological procedure making it possible to broaden the zone of uniform spraying without worsening the properties of the films is a substantial (up to 60 Pa) increase in the pressure of the argon-oxygen mixture. With p = 60 films are obtained with good structural and superconducting characteristics on microwave-traditional substrates with a diameter up to 50 mm. It was found that the greatest role of different technological

factors on structural perfection, areal thickness uniformity and composition of this film is played by the temperature of epitaxial growth, gas mixture pressure and magnetic field distribution of the magnetron device. Figures 4; references 12: 2 Russian, 10 Western.

Interaction Between $YBa_2Cu_3O_{7-y}$ Films and ZrO_2 (Y_2O_3) Substrates

937J0116L Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 6 Nov 92) pp 777-785

[Article by D. G. Andrianov, A. G. Yefimov, S. O. Klimonskiy, S. P. Kobeleva, V. A. Kusikov and Ye. A. Khalyavin, Giredmet Scientific Research Institute]

[Abstract] Since ZrO_2 is among the materials which chemically interact with YBCO at high temperatures, a special study was made of the transition layer between the HTSC film and the substrate. The film-substrate or film-buffer layer was investigated for YBa_2Cu_3 films sprayed in situ by two synchronized pulsed IR lasers on a $ZrO_2(Y_2O_3)$ substrate or sapphire with an amorphous buffer layer (BL) of $ZrO_2(Y_2O_3)$. For this purpose use was made of x-ray photoelectronic spectroscopy, making it possible to detect in the transition region a layer consisting of a mixture of conducting and nonconducting regions, and x-ray diffraction methods, making it possible to determine the thickness of a layer which is transitional in its structure. The results obtained by the two methods are quite consistent and give evidence of an increase in the transition layer thickness with an increase in film thickness. An increase in yttrium concentration in the transition layer region was discovered. The possible dependence of structural perfection and superconducting properties of the films on the Y_2O_3 concentration in the substrates is discussed. Figures 5; references 15: 9 Russian, 6 Western.

Structural Diagnostics and Research on Low-Frequency Current Noise of Anisotropic YBaCuO Films on $LaAlO_3$ Substrates

937J0116M Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 12 Nov 92) pp 786-796

[Article by I. A. Khrebtov, V. N. Leonov, V. I. Kozub, M. V. Belousov, V. Yu. Davydov, S. F. Karmanenko, S. G. Konnikov, N. N. Faleyev and R. Chakalov, State Optical Institute imeni S. I. Vavilov Scientific Center; Physical Technical Institute imeni A. F. Ioffe, Russian Academy of Sciences; St. Petersburg State University; St. Petersburg Electrotechnical University]

[Abstract] A study was made of the structure and low-frequency noise of $YBa_2Cu_3O_{7-\delta}$ films on $LaAlO_3$ substrates. Noise measurements in the temperature range 79-300 K in the frequency range 10-6 x 10^4 Hz revealed the presence of at least two sources of current noise. One of these is related to the imperfection of film structure and is manifested in a resistive state; the other is caused by the movement of a magnetic flux trapped by the film and is observed in a superconducting state. The influence of the strength and direction of the magnetic field on the noise of films in a superconducting state was studied. The possible mechanisms of low-frequency current noise are discussed. The temperature, current and magnetic dependencies of low-frequency noise of anisotropic YBaCuO films have regularities in common with those observed for isotropic films. Noise with a spectrum 1/f when $T > T_c$ increases with temperature, but in the upper part of the transition is proportional to resistivity. Noise in the tail of the transition is expressed as a broad hump together with narrow peaks. Their intensity and position on the temperature scale are dependent on the current and the magnetic field. The spectra in the peaks in many cases deviate greatly from the 1/f dependence. Figures 8; references 14: 5 Russian, 9 Western.

Study of Oxide Growth for Manufacturing $DyBa_2Cu_3O_x$ HTSC Films and Structures Based on Them by Molecular Beam Epitaxy Method

937J0116N Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 8 Oct 92) pp 797-806

[Article by V. V. Mamutin, P. S. Kopyev, A. V. Zakharevich, N. F. Kartenko, V. M. Mikushkin and S. Ye. Sysoyev, Physical Technical Institute imeni A. F. Ioffe, Russian Academy of Sciences]

[Abstract] Using the methods of x-ray photoelectronic spectroscopy and x-ray structural analysis, by means of monitoring the elemental and chemical composition and crystal structure, a study was made of the processes of low-temperature growth of crystalline films of the oxides of metals entering into the composition of the HTSC $Dy_1Ba_2Cu_3O_x$. The binding energies of the fundamental atomic levels of the oxides were determined. It was established that films of the oxides of dysprosium (Dy_2O_3 and barium (BaO) grow in a flow of molecular oxygen in a wide range of velocities and growth temperatures, whereas films of copper oxide (CuO) grow only with the simultaneous operation of three factors: presence of activated oxygen, low rate of growth (< 0.4 A/s) and low substrate temperature (< 440°C). The results of these investigations made it possible to obtain on $NdGaO_3$ substrates with a growth temperature 410°C monocrystalline $Dy_1Ba_2Cu_3O_x$ films superconducting in the entire volume with a surface perpendicular to the c axis and with a c parameter which in films in situ fell in the range 11.85 A-11.72 A and decreased to c = 11.70 A after annealing in oxygen (400°C, 3 hours, 1 atmosphere). The critical temperature of such films was T_c = 88 K. Figures 3; references 14: 2 Russian, 12 Western.

Variation of Critical Temperature, Resistivity and Critical Current of Epitaxial $Bi_2Sr_2CaCu_2O_x$ Films Under Influence of Radiation Defects Induced by Ion Irradiation

937J0116O Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 5 Nov 92) pp 807-822

[Article by V. F. Yelesin, I. A. Yesin and I. A. Rudnev, Moscow Physical Engineering Institute; B. L. Krivtsov and Ye. P. Limitovskiy, Electronic Technology Materials Scientific Research Institute]

[Abstract] A study was made of the influence of radiation defects created by helium ions (E = 1.2 MeV) on the critical temperature, resistivity, critical current and broadening of the superconducting transition in the magnetic field of epitaxial $Bi_2Sr_2CaCu_2O_x$ films prepared by the liquid-phase epitaxy method. The character of change in critical temperature and resistivity of such epitaxial films with the introduction of radiation defects is similar to that observed for compounds of the Y-123 type and the superconductor Nd(Ce)-Cu-O. The dependencies of T_c, $\rho(T)$ and J_c on fluence were determined and the mechanisms of changes in superconducting properties and suppression of superconductivity in HTSC compounds based on bismuth are discussed. It was found that there is a J_c increase in a wide range of magnetic fields including in the zero field, and a simultaneous decrease in the width of the superconducting transition in the magnetic field. The latter circumstance supports the mechanism of broadening of the superconducting transition in the magnetic field due to a magnetic flux flow. There evidently are two different mechanisms of superconductivity suppression, each of which is manifested more strongly when there is a definite concentration of defects. Figures 12; references 40: 9 Russian, 31 Western.

Fast Current S-N Switching-Over of $YBa_2Cu_3O_{7-x}$ Films and Its Application for Amplitude Modulation of Microwave Signal

937J0116P Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 20 Oct 92) pp 823-837

[Article by A. B. Kozyrev, T. B. Samoylova and S. Yu. Shaferova, St. Petersburg State Electrotechnical University]

[Abstract] In earlier studies the authors investigated the process of S-N switching of granulated and highly oriented HTSC films irradiated by microwave pulses. Attention is now directed to the mechanisms of S-N switching of highly oriented YBaCuO films under the influence of videopulses. As an illustration of the possibility of practical use of the studied phenomena experimental data are given on the parameters of a pulse-controlled modulator when using a YBaCuO film for the lower part of the microwave range. (A diagram of the apparatus accompanies the text, which fully describes its operation.) Studies were made of the processes of destruction of superconductivity under the influence of supercritical current pulses in broad (w λ) highly oriented $YBa_2Cu_3O_{7-x}$. It is shown that the time of switching from a superconducting to a normally conducting state is $\tau_{S-N} < 3 \times 10^{-10}$s. A more precise determination of τ was limited by the capabilities of the measuring instruments. Theoretical estimates give values $\tau_{S-N} \leq 10^{-12}$ s. The possibility of practical use of the effect of fast current S-N switching of superconducting films is illustrated in the example of a microwave switch-modulator (f = 1.5 GHz, intensity of pulse modulation about 20 db). Figures 7; references 17: 9 Russian, 8 Western.

Microstructure Formation in High-Temperature Superconducting Films Using Laser Holography

937J0116Q Moscow SVERKHPROVODIMOST: FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 9 Nov 92) pp 838-842

[Article by A. A. Blyablin, A. V. Kandidov, A. S. Kovalev, V. V. Korneyev and B. V. Seleznev, Nuclear Physics Scientific Research Institute, Moscow State University]

[Abstract] A method was developed for creating planar structures on thin epitaxial high-temperature $YBa_2Cu_3O_{7-x}$ films based on modification or elimination of unnecessary film fragments under the influence of radiation from a pulsed laser. A selectivity of the effect is attained by the diffraction of laser radiation on a preregistered mask hologram. The experiments were made using films obtained by the laser ablation method. The films were sprayed in situ onto substrates of the monocrystal $SrTiO_3$ (100) using a KrF pulsed laser (λ = 248 nm). The substrate was positioned 3 cm from the target in a heater having a temperature 850°C. Oxygen pressure in the chamber was 200 mm Hg. A rotating quartz lens scanned the focused laser ray over the target surface. The target used was a ceramic YBCO tablet of a stoichiometric composition; pulse power was 200 mJ; pulse duration was 30 ns; energy density on the target was maintained at 1.5 J/cm^2. A diagram illustrates image registry in the hologram and image retrieval from a hologram onto the surface of a YBCO film; each step in the procedure is described in detail. Good results were obtained with the irradiation of the film from the direction of a transparent substrate. The dependence of the processes transpiring at this time on laser pulse energy density was investigated. Figures 3; references: 11 Western.

Unified Homologous Series in A-B-O System (A = Ca, Sr, Ba, La, Y; B = Cu, Bi, Tl, Pb)

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[Article by L. A. Klinkova, Solid State Physics Institute, Russian Academy of Sciences]

[Abstract] Double and complex nonsuperconducting and superconducting oxides of the perovskite type are systematized by composition and it is shown that they all are terms of a single homologous series $A_mB_{m\pm n}O_y(A_{m\pm n}B_mO_y$, where A = Ca, St, Ba, Y, Ln; B = Cu, Bi, Tl, Pb, m = 1, 2, 3,..., n = 0, 1, 2, 3,... and $0 \leq n \leq 2m$. The oxide ABO_y is the parent structure of double oxides of this series. Superconducting complex oxides are substitutional solid solutions based on double oxides and inherit the principal structural elements of the latter: the absence or presence of double and triple A and B planes. It is shown that in the series $A_mB_{m\pm n}O_y$ ($A_{m\pm n}B_mO_y$) in the structural and superconducting properties, attaining optimum values in an ABO_y composition. The cited homologous series provides for unknown compositions of oxides in the A-B-O system. Among the useful tables included (and which are used in the analysis) are the following:

Characteristics of Calcium Cuprates and Bismuthates;

Characteristics of Strontium Cuprates and Bismuthates;

Characteristics of Barium Cuprates and Bismuthates;

Composition and Parameters of Crystal Lattice of Nonsuperconducting Complex Oxides;

Characteristics of Nonsuperconducting and Superconducting Oxides—Derivatives of Barium Cuprates and Bismuthates;

Composition and Properties of Superconducting Complex Oxides—Derivatives of Strontium Cuprates and Bismuthates. Figures 4; references 95: 13 Russian, 82 Western.

Superconducting Induction Switch Controlled by Pulsed Magnetic Field

937J0116S Moscow SVERKHPROVODIMOST': FIZIKA, KHIMIYA, TEKHNIKA in Russian Vol 6 No 4, Apr 93 (manuscript received 23 Nov 92) pp 873-889

[Article by V. V. Ivanov, S. N. Paranin, D. V. Sannikov, A. N. Vikhrev, O. M. Zhdanok and V. R. Khrustov, Electrophysics Institute, Ural Department, Russian Academy of Sciences]

[Abstract] A model of a rapidly acting inductive superconducting switch operating on the principle of an induction change with the attenuation of screening currents in a superconducting ceramic tube is proposed. Switch impedance increases during a time less than 100 ns with exposure to the controlling pulse of a magnetic field with an amplitude about 0.1T. The appearance of switch impedance is associated with a transition of the superconductor to a resistive state and the impedance is operative during the course of attenuation of screening currents in the tube. With a diameter of the HTSC tube 33 mm and a height 14 mm the switched pulse power attained 200 W with an impedance 0.1 ohm over a time more than 200 μs. The dynamics of diffusion of pulsed magnetic fields in a ceramic containing bismuth under conditions of operation of such an inductive switch was studied. The time of maintenance of switch impedance (open state) is determined by the dynamics of attenuation of currents in the HTSC screen which is in a resistive state; when using a closed magnetic circuit this may be hundreds of microseconds or more. The screening HTSC element has no contacts and does not require special protection against thermal overheating by the current during transition into a resistive state. The inductive switch can be used for the switching of pulsed currents with an amplitude exceeding the critical current of a superconducting element by an order of magnitude. Figures 12; references 13: 3 Russian, 10 Western.

Possibility of Using High-Power Microwaves in Technology

947J0004A Moscow DOKLADY AKADEMII NAUK in Russian Vol 331 No 5, Aug 93 (manuscript received 6 Oct 92) pp 571-572

[Article by A.N. Didenko, corresponding member, Russian Academy of Sciences, Moscow Institute of Engineering Physics; UDC 621.384.6]

[Abstract] A recent achievement in relativistic microwave electronics is conversion of the energy of high-current electron beam energy into energy of centimeter-wave and millimeter-wave electromagnetic radiation pulses, pulses of nanosecond duration and gigawatt power. Oscillators generating such radiation pulses are already used for scientific purposes, two of them being: 1. high-resolution radar, 2. particle accelerator for linear electron-positron colliders operating with an intensity about 1 MeV/cm. Both applications require a high stability of the microwaves within a pulse. Under consideration is now the possibility of also using such oscillators for technical purposes, considered, particularly advantageous being their operation with electromagnetic fields of intensities not attainable by means of technological continuous-wave oscillators. Pulsed action thus can, more than continuous action, significantly influence processes in any given medium and especially so a system consisting of two or more media. A typical example is a layer of a dielectric or weakly conducting material deposited on a metal surface. Electromagnetic microwave energy incident on the dielectric layer will pass through that layer almost without losses and then, under certain conditions, be almost all released in the metal skin layer. A key factor determining the effectiveness of this treatment thus will be the skin depth of the metal substrate. The problem is to ensure that the treated surface adsorb up to 50% of all the incident microwave energy and that the metal skin layer then absorb this energy for heating up, which may be difficult owing to the high microwave conductivity of metals. For a theoretical analysis of this problem, pulses of microwave radiation are regarded as a heat source. The evolution of the temperature field in the skin layer is described by the solution T(x,t) to the one-dimensional Tikhonov-Samarskiy equation of transient heat conduction, from which then the temperature rise time to its maximum. Numerical calculations made on this basis for microwave heating of copper and iron skin layers from room temperature to about 100°C have yielded an energy requirement of about 0.15 J/cm^2 and 0.5 J/cm^2 respectively, the temperature of the adjacent dielectric layer not significantly rising in the process. Effective heating of a metal skin layer by nanosecond microwave radiation pulses is thus theoretically possible, but requires pulses delivering a power of about 100 MW/cm^2 density. Sources of such pulses are so far not available and now only progress in relativistic microwave electron devices can lead to the desired goal. One possible application would be removal of dielectric or weak-conductor coatings from metal surfaces. The dielectric layer will split off owing to thermal expansion of the metal substrate, but only when the stress induced in it exceeds the breaking stress. Other possible applications would be removal of oxide films from metal blades of aircraft engines, descaling boiler surfaces, and removal of shell rock from underwater ship surfaces. The advantage over mechanical is the substantially lower energy expenditure per unit weight of removed material. References 4.

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